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ARL 62-415
SUPPLEMENT I

A PORTABLE LOW-LEVEL LIGHTMETER
I: LOW-LEVEL LIGHTMETER FOR THE NEAR INFRARED

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SOLID STATE PHYSICS RESEARCH LABORATORY

AUGUST 1962

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AERONAUTICAL RESEARCH LABORATORIES
OFFICE OF AEROSPACE RESEARCH
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PROJECT 7072
TASK 70827

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UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

FOREWORD

This technical documentary report was prepared by Mr. R. K. H. Gebel of the Solid State Physics Research Laboratory, Aeronautical Research Laboratories, Office of Aerospace Research, United States Air Force. The work reported herein was performed on Task 70827, "Light Amplification" of Project 7072, "Research on Quantum Nature of Light".

This report supersedes WC RR TN 54-5, Supplement I, dated March 1955.

Abstract

Results of former attempts to establish a value for visible radiation in the region between 7000 and 11,000 Å in the near infrared of the night sky have been unreliable due to lack of precision instruments. In this modification for the low-level lightmeter, an infrared image-converter tube for converting the infrared into visible radiation has been employed. Further, better stabilization in the transformer and change of voltage in the photomultiplier are made to achieve a higher sensitivity of the meter. Calibrations were made similarly to the method explained in "Portable Low-Level Lightmeter." Improvement in registering the brightness of the night sky in the near infrared (6300 to 11,000 Å) was noted.

A Portable Low-Level Lightmeter

Supplement I: Low-Level Lightmeter

for the Near Infrared

Radames K. H. Gebel

Measurements made by Krasovsky and Lukashenia^{1,2} indicate that there are several very strong bands of radiation from the night sky in the near infrared. Visible radiation in the 10,000 Å band is believed to be 50 times stronger than that in the 5700 Å band, but an integrated value for the whole region between 7000 and 11,000 Å is not available. Measurements performed up to the present have not been very reliable due to lack of precision instruments with sufficiently high sensitivity; and the available measurements do not cover continuously the night sky radiation from 6300 to 11,000 Å. Therefore, modifying the low-level lightmeter for the near infrared (6300 to 11,000 Å) is very important. Since the photomultiplier tube, a 1P21, used in the low-level lightmeter has a spectral response which has practically no sensitivity in the near infrared and since there was no photomultiplier with an infrared sensitive photocathode available, several modifications on the low-level lightmeter were necessary.

For immediate results the best conceivable idea seemed to be to set an image-converter tube with an S1 photocathode and a P1 phosphor screen between the optic and the photomultiplier tube. Figure 1 shows a schematic for the new low-level lightmeter for visible and infrared light. A two-electrode miniature image-converter tube, the Farnsworth 1C6, was selected as suitable and the photomultiplier tube was changed from the 1P21 to the RCA 5819 with an S9 response to collect all the light produced by the screen of the image-converter tube. To achieve the highest possible sensitivity, the vibrator was stabilized by two glow-discharge stabilizer tubes. Since these have a different firing potential for reversed voltages, two glow-discharge tubes with opposite polarity were necessary. The resistor R2 was added to the resistance of the transformer, T-1, for better stabilization and for limitation of the current. Partial compensation for the

1. V.I. Krasovsky and V.L. Lukashenia, "On the Question of the Identification of the night Sky Spectrum in the Neighborhood of 10,000 Å," DRB, Canada, 15 August 1952, T74 R.

2. V.L. Lukashenia and V.I. Krasovsky, "On the Reproducibility of the Night Sky Spectrum in the 8000 to 9000 Å Neighborhood as obtained by Meinel," DRB, Canada, January 1953, T75 R.

loss in voltage produced by the stabilizing arrangement required the use of the 5-volt center-tapped winding of the transformer instead of the 6.3-volt center-tapped winding previously used. The zero point on the scale of the high-sensitive meter will change approximately only 1-scale division if the battery voltage changes 0.1 volt. This change is unimportant since the zero point is checked before and after each measurement. The change in the sensitivity of the meter will be less than 1 percent if the battery voltage changes 0.1 volt. This is also negligible. The voltage applied to the photomultiplier tube was changed from ac to dc which is obtained from a voltage-doubler circuit.

Calibration of the lightmeter was similar to that described in the basic report entitled "Portable Low-Level Lightmeter." The threshold sensitivity (1-scale division) of this unit was determined at 8000 Å to be $3.5 \cdot 10^{-5}$ foot lambert where the definition of a near infrared lumen (8000 Å) was arbitrarily made equivalent to $1.3 \cdot 10^{16}$ quanta/sec. Therefore,

$$1 \text{ 8000 Å foot lambert} = \frac{1.4 \cdot 10^{11} \text{ Quanta}}{\text{mm}^2 \cdot \text{sec}}$$

$$1 \text{ 8000 Å quantum} = 2.5 \cdot 10^{-20} \text{ mkg,}$$

$$\text{and } 1 \text{ 8000 Å lumen} = 3.18 \cdot 10^{-3} \text{ watt.}$$

On 8 March 1955 a night test was performed with this type of infrared lightmeter. The evening was windy with no clouds and the temperature was 45° F. Two filters of the Wratten 88 A type were used. At 2215 hours the brightness of the night sky in the near infrared registered by this instrument was $1.5 \cdot 10^{-4}$ foot lambert, (figure 2).

Note 1

When using germanium or silicon diodes for rectification or voltage doublings, careful matching for back resistance must be used. If proper matching is achieved, the number of diodes in series may be reduced. Maximum reverse working voltage for 1N39 is 200 volt dc.

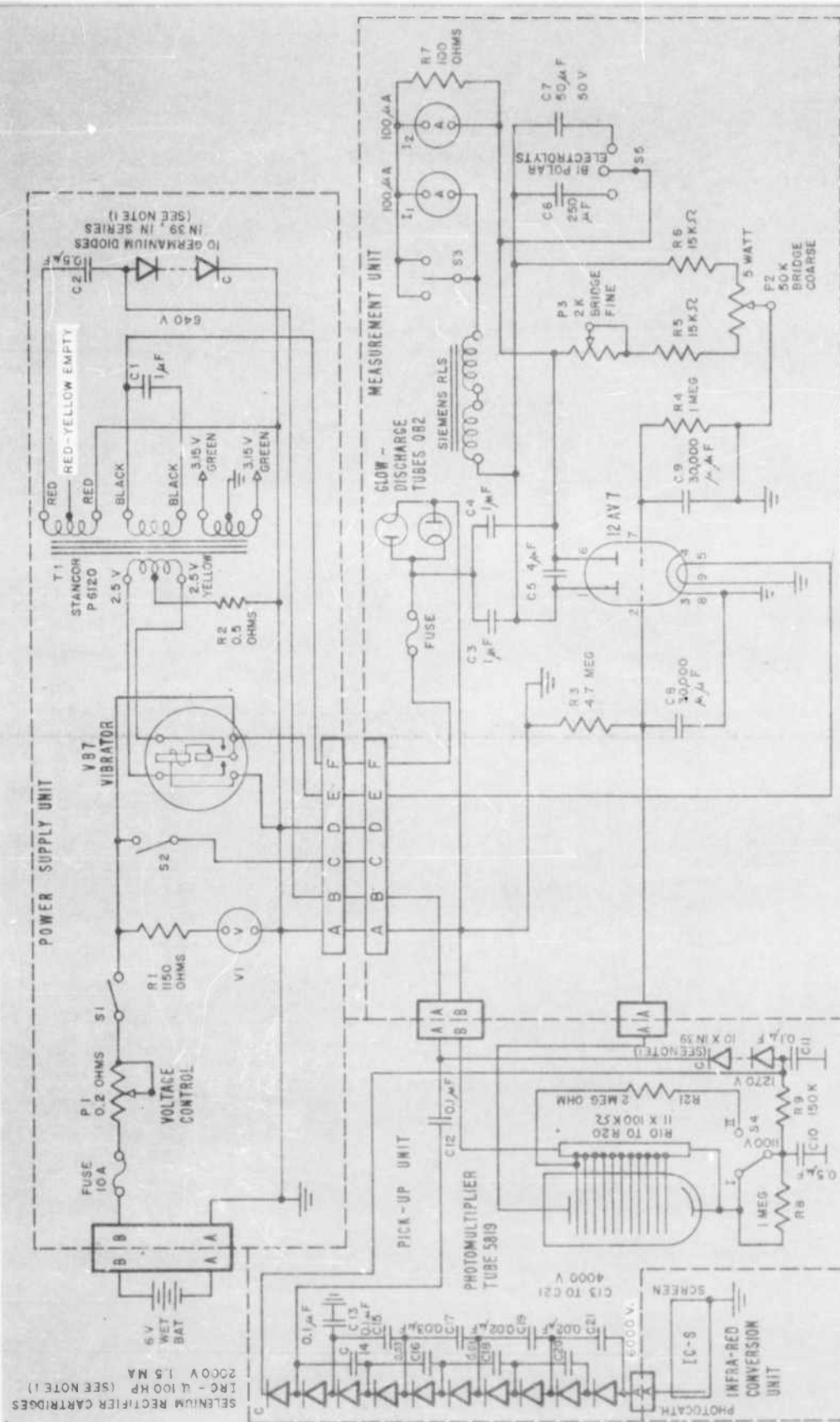


Figure 1. Schematic Diagram for Low-Level Lightmeter with Near-Infrared Conversion Unit

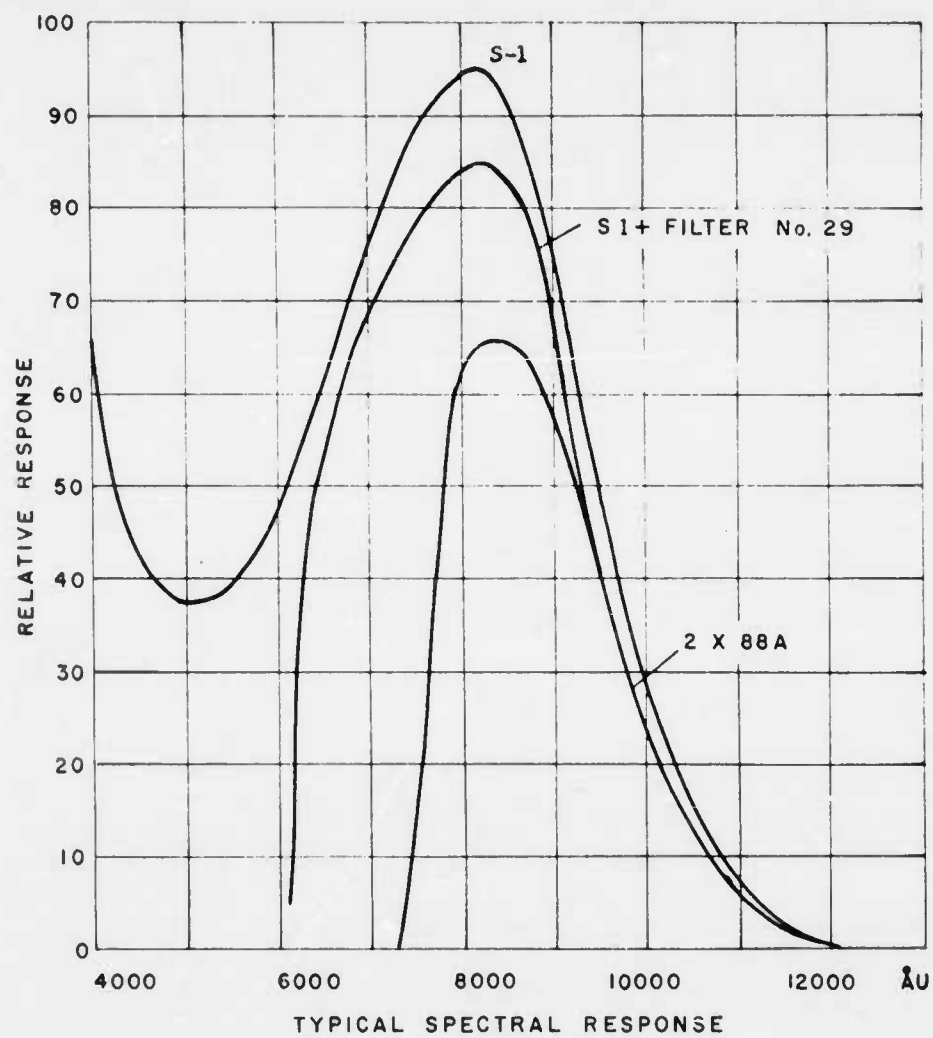


Figure 2.

<p>Aeronautical Research Laboratories, Wright-Patterson AFB, Ohio. A PORTABLE LOW-LEVEL LIGHTMETER, I: LOW-LEVEL LIGHTMETER FOR THE NEAR INFRARED by R. K. H. Gebel, Solid State Physics Research Laboratory, August 1962. 4 p. incl. illus. (Project 7072; Task 70827) (ARL 62-415, Supplement I). Unclassified Report</p> <p>Results of former attempts to establish a value for visible radiation in the region between 7000 and 11,000Å in the near infrared of the night sky have been unreliable due to lack of precision instruments. In this modification for the low-level lightmeter, an</p> <p>(over)</p>	<p>UNCLASSIFIED</p>	<p>UNCLASSIFIED</p>
<p>infrared image-converter tube for converting the infrared into visible radiation has been employed. Further, better stabilization in the transformer and change of voltage in the photomultiplier are made to achieve a higher sensitivity of the meter. Calibrations were made similarly to the method explained in "Portable Low-Level Lightmeter". Improvement in registering the brightness of the night sky in the near infrared (6300 to 11,000Å) was noted.</p> <p>(over)</p>	<p>UNCLASSIFIED</p>	<p>UNCLASSIFIED</p>
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